Telemetric tracking of Green Sea Turtles (*Chelonia mydas*) in Relation to Dredged Channels at South Padre Island, Texas July Through September 1992

By

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EXECUTIVE SUMMARY

Hopper dredging by the U.S. Army Corps of Engineers (COE) has been identified as a notable source of mortality to sea turtles in inshore waters (Dickerson and Nelson 1990; Magnuson et al. 1990). Maintenance dredging of intracoastal waterways and about 45 ship channels in the Gulf and Atlantic, disposal of dredged materials, beach nourishment and marine construction (Thompson et al. 1990) all pose risks to sea turtles. Resolution of sea turtle/industry conflicts such as channel dredging, and implementation of proper management of existing stocks are severely compromised by the paucity of quantitative data on species composition, size distribution, spatial and temporal abundance, habitat preference, feeding grounds and nesting activity of sea turtles in nearshore and estuarine waters of the northwestern Gulf.

Texas waters provide essential habitat for Kemp's ridley and green sea turtles. Until recently, virtually no research had been conducted on sea turtle populations in Texas. Tracking and mark-recapture studies on green sea turtles in south Texas and numerous sightings by the public at jetties and channel entrances along the central and south Texas coast during the summer suggest these areas serve as developmental habitats for juvenile and subadult sea turtles.

Tracked turtles exhibited home ranges along the jetties from 400 to 1350 m. However, core areas, defined as the region in which the turtle spent more than 50% of its time during the study, were usually < 100 m in extent except where bi- or trimodal cores occurred. In the latter case, the modes, still < 100 m in extent were up to 250 m

apart. Sheltered areas were included in all turtle home ranges. In most cases, the distribution of individual sea turtles at night was more restricted than during the day. Turtles moved if adverse weather conditions altered the serenity of a core area.

At least two types of submerged behavior of the sea turtles were noted, foraging and resting. Active periods (submergence < 5 min) of foraging and feeding occurred mostly during dusk and dawn. These observations reflected sea turtle affinity for the rock jetty habitat. Resting behavior (submergence $\geq$ 10 min), was observed at night and minimally during the afternoon. Little or no movement was noted for any of the sea turtles monitored at night.

Utilization of the Brownsville Ship Channel by juvenile green sea turtles should be considered rare. Movement immediately after release indicates that the channel may be used as an escape route when turtles are disturbed. Our data suggest that turtle diving activity varies by time of day. Transient use of the channel may occur when a green sea turtle crosses the channel from one jetty to another or when the channel is used for passage to enter the Laguna Madre. During these times (< 0.3% in our study) turtles might be susceptible to hopper dredging. Our tracking information suggests that movement behaviors of juvenile green sea turtles in the Brazos-Santiago Pass area does not threaten their lives with respect to biannual hopper dredging.

This study expands our knowledge of movement and feeding behavior of juvenile green sea turtles at Brazos-Santiago Pass and the Brownsville Ship Channel, South Padre Island, Tx. However, these

conclusions should not be extended to other sea turtle species. Information needs to be collected on different species of sea turtles as their behaviors undoubtedly will vary.

INTRODUCTION

Recovery and management of endangered sea turtle stocks of the Gulf of Mexico were addressed by a 1989 Minerals Management Service Workshop on Marine Mammals and Turtles in the Gulf of Mexico and later in a Marine Turtle Habitat Plan developed by the National Marine Fisheries Service (NMFS) (Thompson et al. 1990). Characterization of turtle habitat was recommended as the most appropriate research approach to recovery and management of Gulf sea turtle stocks, with the highest priority assigned to Kemp's ridley Lepidochelys kempi and green sea turtles Chelonia mydas.

Texas waters provide essential habitat for both these species. Until recently, virtually no research had been conducted on sea turtle populations in Texas. Historically, the lower Laguna Madre in south Texas has been a very important habitat for sea turtles, especially the green sea turtle. In 1890 the commercial fishery in the lower Laguna Madre, Texas, accounted for 22,000 kg of sea turtles. By 1900 these sea turtles had been overexploited and the fishery collapsed (Doughty 1984). Nesting activity and stranding frequency have been documented for sea turtles along south Texas beaches (Francis 1978; Rabalais and Rabalais 1980; Shaver 1990a). Tracking and mark-recapture studies on green sea turtles in south Texas (Manzella 1990; Renaud et al. 1992; Shaver 1990b) and numerous sightings by the public at jetties and channel entrances along the central and south Texas coast during the summer suggest these areas serve as developmental habitats for juvenile and subadult

sea turtles (Williams and Manzella 1990; Williams and Manzella 1992).

Hopper dredging by the U.S. Army Corps of Engineers (COE) was identified as a notable source of mortality to sea turtles in inshore waters (Dickerson and Nelson 1990; Magnuson et al. 1990). Maintenance dredging of intracoastal waterways and about 45 ship channels in the Gulf and Atlantic, disposal of dredged materials, beach nourishment and marine construction (Thompson et al. 1990) all pose risks to sea turtles. Resolution of sea turtle/industry conflicts such as channel dredging and implementation of proper management of existing stocks are severely compromised by the paucity of quantitative data on species composition, size distribution, spatial and temporal abundance, habitat preference, feeding grounds and nesting activity of sea turtles in nearshore and estuarine waters of the northwestern Gulf.

We have hypothesized that jetty passes and associated dredged channels are important human-made habitats used by young sea turtles. Due to continued concern by the Galveston and New Orleans Districts of the COE, they funded a plan to study sea turtle behavior near dredged channels for a second consecutive year. The objective of our study was to evaluate juvenile sea turtle movements and to determine habitat preferences at Brazos Santiago Pass, Texas. A companion report which adds to the value of this study has been prepared by Texas A&M University, Institute of Marine Life Science, under a separate contract. That report characterizes sea turtle habitat in the area of our study.

MATERIALS AND METHODS

Study Area

The study was conducted in 5 relatively discrete regions of the Brazos Santiago Pass at South Padre Island, Texas (Fig. 1). These regions include: 1) the south side of the south jetty, 2) the north side of the south jetty, 3) the south side of the north jetty, 4) the north side of the north jetty and 5) the Brownsville ship channel (BSC) between the jetties. Barracuda and Dolphin Coves are located at the innermost reaches of the jetties on the south and north sides, respectively.

Capture of Sea Turtles

Sea turtles were captured by Texas A&M personnel, with 91.5 m long entanglement nets of 2 depth and mesh size specifications deployed in 2 configurations. These nets were 3.7 m deep with 12.7 cm bar mesh of #9 twisted nylon or 4.9 m deep with 25.4 cm bar mesh of #9 twisted nylon. Several areas along the jetties including those in Dolphin and Barracuda Coves were sampled during the day with 1-4 stationary entanglement nets (of similar or mixed specifications) set adjacent to one another for 8 to 12 hr. Sampling at the deeper jetty habitat was modified to a more active capture method of encircling turtles with entanglement nets. The encirclement technique was attempted only when 1) a turtle exhibited a sustained ($\geq$ 30 min) pattern of surfacing and sounding which became predictable and 2) surfacing occurred no more than 10 m from and along a 30 m length of the jetty. Encircling began about 1 minute before the predicted surfacing

time by securing 1 end of the net to the jetty and quickly encircling the expected surfacing spot with the remaining net deployed from a boat. The net was brought to the jetty to create a "semi-circle" of netting around the turtle. Divers entered the encircled area to close off any escape route and to catch or maneuver a turtle into the net. Cast netting was used to supplement the encirclement technique.

Tagging Activities

Immediately following capture, all turtles were transported to the University of Texas Pan American Coastal Studies Laboratory on South Padre Island and held for 24-72 hrs before being released. Straight line and curved carapace length and width were measured to the nearest 0.1 cm. Turtles were photographed and placed in 3.0-m diameter fiberglass holding tanks.

Radio transmitters (164.0-165.0 Mhz) were fiberglassed to the second neural scute of each sea turtle while sonic transmitters (32-40 Khz) were bolted to the posterior marginal scutes. Time depth recorders (TDRs) and additional sonic and radio tags were encased in a styrofoam float and bolted to the posteriormost marginal scute of the 2 largest sea turtles. A dissolving "pop-up" link was placed between the turtle and the float allowing the floating package to detach and be retrieved within a 7-10 day period.

Sea turtles were tagged on the left front flipper using Hasco style 681 inconel tags. Finally, for easy identification

in the field, white epoxy paint was used to draw a unique number on the carapace of each turtle. Sea turtles were released at their capture site. All turtles in this report are referred to by the last 4 numbers of their radio frequency preceded by the letter T. The smallest turtle could only accommodate a sonic transmitter, and was referred to as T0000.

Tracking

Radio transmitters were monitored using a Telonics TR2/TS1 receiver/scanner connected to a directional 5-element Yagi antenna. Reception of radio signals varied between 10-16 km depending on the height of the receiver antenna. Sonic transmitters were monitored using a directional hydrophone with a receiving range between 0.6 and 1.1 km.

Data collection occurred over the entire 24-hr daily cycle. Attempts to locate all sea turtles were made daily. Three or more sea turtles were tracked for extended periods during each day from 31 July through 26 September, 1992. A 3-day follow-up trip in October provided additional information on sea turtle locations. Geographic location was recorded when sea turtles were visually sighted or their position was pinpointed with sonic telemetry.

Reference marks were painted at 46 m (50 yd) intervals on the rocks, shoreward from the seaward tip of the jetties. The location of sea turtles was determined by their position with respect to reference marks and their perpendicular distance from the jetties. Sea turtle locations more than 40 m away from the

rocks were recorded using a portable Global Positioning System (GPS), if possible.

Environmental Data

Surface water temperature and salinity were recorded using mercury thermometers (-30^{o}C to +50^{o}C) and refractometers approximately every 30 min while tracking the sea turtles.

Habitat Characterization

Twelve stations were characterized along the Brazos-Santiago Pass jetties; 7 for the south jetty and 5 for the north jetty. Hydrological monitoring, sediment analyses, vegetation characterization were conducted at each station. Trawling at 6 additional sites, 2 on the north jetty and 4 on the south jetty, further characterized the biota. Landry et al. (1993) provide specific information on these procedures and subsequent habitat characterization.

Habitat Preferences

Habitat preferences were determined by 1) monitoring locations of sea turtles during tracking activities and 2) analyzing information from the time-depth recorder on 1 of the larger sea turtles. Turtle locations along the jetties were plotted to develop linear home ranges. Locations were weighted according to length of observation. Weighted locations were then grouped into 46 m intervals and a frequency distribution performed. This frequency distribution was used to determine the core area, defined as the region in which the turtle spent more than 50% of its time during the study. Core areas were

determined for dawn (0500 - 0900), day (0900 - 1700), dusk (1700 - 2100), and night (2100 - 0500) if at least 3 different days were sampled and > 5 hr of tracking information were available for a turtle within a time.

Surface and Submergence Behavior

Surface and submergence times were calculated for each turtle with a radio transmitter. Surface times were determined by recording the interval between the beginning and ending of radio signals. Submerged times were determined by recording the interval between the end of a radio signal and the beginning of the next. Overall mean surface and submergence times were calculated as well as hourly means and day, night, dawn, and dusk means. When a surface or submergence interval included 2 time periods, it was placed in whichever period contained the majority of the interval.

Since T4698 spent time both at the jetties and in South Bay, the data for determining surface and submerged times were divided into jetty and South Bay locations to allow comparison of submergence behavior between the 2 habitats. Analysis of variance (Tukey-Kramer method) was used to test for significant differences in mean surface or submergence times by time period (day, night, dawn, dusk) at $p = 0.05$. Data collected the day of release were not used in analysis as it was considered release behavior and not representative of typical surface/submergence behavior.

For each TDR retrieved, data beginning 2 hr after release

were grouped into 1 m depth intervals and sorted into a frequency distribution. Frequency distributions and analysis of variance of mean depths using the Tukey-Kramer method at p=0.05 also were performed with the data grouped by date and by time of day (dawn, day, dusk, night).

RESULTS

Capture and Tagging of Sea Turtles

Ten green sea turtles were captured adjacent to the jetties of Brazos-Santiago Pass. They were fitted with combinations of radio and sonic transmitters and released at their capture sites. Capture dates and locations, morphometrics, tag numbers and radio/sonic transmitter frequencies of the sea turtles are given in Table 1.

Sea Turtle Movement Patterns

All turtles moved away from the jetties immediately following their release. Seven turtles on the channel side of the jetties entered the deeper waters of the BSC (Fig. 2). Five of the turtles returned to, or near their capture site within 30 min. The remaining 2 swam directly offshore. By the following day, one of the latter 2 turtles returned to its release site while the other took up residence on the Gulf side of the north jetty. Three turtles released on the Gulf side of the south jetty swam south along Boca Chica Beach. One returned to its capture site within an hour. A second moved to the north side of the south jetty within an hour. The third turtle did not return to the jetties for 9 days.

Daily movements of turtles ranged from less than 46 m to more than 1000 m. Seventy percent of all locations were within 5 m of the jetties, while only 0.3% were within channel boundaries. Data from the time-depth recorder indicated that T5341 made 93%

of its submergences in water < 7 m. Only 2% of its submergences were in possible channel habitat (> 13 m-depths). Home ranges of the turtles that remained in the jetties area were from 366 to 1235 m long. Overall core areas ranged in size from 46 to 183 m. When observations were grouped by time of day, core areas varied from 46 to 275 m.

Sea turtles were tracked about twice as many hours during morning and afternoon as in 1800 to 2400 hr. Total tracking hr, by hour of day for each turtle, is presented in Figure 3. Total tracking hours include simultaneous radio and sonic tracking, sonic tracking only, radio tracking alone, and visual tracking. Sonic tracking alone occurred under 2 different situations: 1) when 2 turtles were inhabiting the same area, one was monitored simultaneously with radio and sonic receivers and the other was spot checked every 10 to 15 min with the sonic receiver, and 2) if a turtle had lost its radio tag it was monitored with the sonic receiver. Radio tracking alone occurred under 2 sets of conditions: 1) when weather prohibited the launching of the tracking vessel, radio tracking was carried out from a land base, and 2) while tracking one turtle with only a sonic tag, the radio receiver was used to gather surface-submergence information on another turtle. Occasionally, visual tracking was carried out from the jetty on turtles that were very habitat faithful.

T5413, captured on 28 July 1992, on the north side of the south jetty (868 m marker), was tracked from 31 July through 26 September 1992. A total of 91.5 hours was expended tracking

T5413 (Fig. 3). It was the largest turtle (47.9 cm straight length) and exhibited the most extensive home range (1235 m) at the jetties. T5413 spent 64% of its time in a 183 m area between meter-markers 915 and 1098 (Fig 4). On 2 occasions, this turtle travelled from Barracuda Cove to the end of the jetties and back toward the shore within 3 to 5 hr. The entire round trips were essentially continuous with a few 10 to 15 minute stops dispersed throughout the trip. Additional radio and sonic transmitters and a time-depth recorder were attached to T5413 by a trailing styrofoam float. The package broke free after one day and was not recovered.

T5341, captured on 30 July 1992, on the north side of the south jetty (914 m marker) was tracked from 1 August through 25 September 1992, (Table 1). A total of 45.8 hours was expended tracking T5341 (Fig. 3). The turtle ranged approximately 1098 m along the north side of the south jetty, but spent 42% of its time between 549 and 595 m from the tip of the jetty and 30% of its time between the 1006 - 1098 m markers. Variability in the location of core areas, by time of day, is presented in Figure 5. A trailing styrofoam package containing radio and sonic transmitters and a time-depth recorder was also attached to T5341. It detached after 4 days. During these 4 days, T5341 spent approximately 3% of its time at BSC depths. It also moved further inland, past Barracuda and Dolphin Coves while the trailing tags were still attached. This wide ranging activity ceased once the float detached, suggesting that these movements

were influenced by the presence of the float. Therefore, these data were eliminated from further analyses. Following float detachment, T5341 spent all of its time very close to the jetties.

T4101, captured on 30 July 1992, on the south side of the north jetty (366 m marker), was tracked from 1 August through 26 September 1992, (Table 1). A total of 58.1 hours was expended tracking T4101 (Fig. 3). T4101 ranged approximately 366 m along the south side of the north jetty, spending 76% of its time within 46 m of its capture site. Variability of T4101's core areas, by time of day, is presented in Figure 6. T4101 exhibited the least amount of movement of the 10 turtles tracked.

T4598, captured on 29 July 1992, on the north side of the south jetty (868 m marker), was tracked from 1 August through 26 September 1992, (Table 1). A total of 86.5 hours was expended tracking T4598 (Fig. 3). T4598 ranged approximately 732 m along the north side of the south jetty, spending 44% and 22% of its time between the 777 - 868 m and 1006 - 1052 m markers (Fig.7).

T5601, captured on 29 July 1992, on the north side of the south jetty (1006 m marker), was tracked from 1 August through 15 October 1992, (Table 1). A total of 84.5 hours was expended tracking T5601 (Fig. 3). T5601 ranged approximately 960 m along the north side of the south jetty, spending 66% of its time between the 1006 - 1098 m markers (Fig. 8).

T5200, captured on 31 July 1992, on the north side of the south jetty (137 m marker), was tracked from 2 August through 26

September 1992, (Table 1). A total of 33.7 hours was expended tracking T5200 (Fig. 3). This turtle moved offshore the day it was released and returned to the north side of the north jetty the next day where it remained for 11 days. T5200 ranged approximately 503 m along the north side of the north jetty, spending 84% of its time between the 274 and 412 m markers. A severe norther, producing waves that broke on top of the jetties coincided with T5200 moving to a more protected area on the north side of the south jetty on day 14. On day 20, T5200 was observed on the south and north sides of the south jetty. The following day T5200 moved to the north side of the north jetty again. It spent 98% of its time between the 46 and 91 m markers during a 21 day period. T5200 moved to the south side of the south jetty on day 25 for the final 20 days of the study, and spent 99% of its time there between the 46 and 91 m markers (Fig. 9). This turtle crossed the BSC at least 4 times.

T4698, captured on 4 August 1992, on the south side of the north jetty (732 m marker), was tracked from 6 August through 26 September 1992, (Table 1). A total of 13.5 hours was expended over a 9 day period tracking T4698 at the jetty habitat (Fig. 3). This turtle swam offshore the day it was released and returned to its capture site by the following morning where it remained for 9 days. T4698 ranged approximately 595 m along the south side of the north jetty, spending 69% of its time between the 640 and 686 markers. During one day, T4698 was detected on the north side of the north jetty between the 229 and 412 m markers. T4698

was tracked across the channel to the north side of the south jetty the day before it moved into South Bay. Variability of T4698's core areas at the south side of the north jetty, by time of day, is presented in Figure 10.

On 15 August 1992, T4698 was noted moving shoreward along the south side of the north jetty. Over a 2-hr period T4698 was tracked as it moved along the jetty, crossed the channel, and moved seaward along the south jetty to within 225 m of its tip. On 17 August, the turtle could not be located with the sonic receiver. On 18 August T4698 was determined to be in South Bay. This turtle spent the final 37 days of the study in South Bay where an additional 64.3 hr of monitoring, mostly radio only, was conducted.

T5801, captured on 8 August 1992, on the south side of the south jetty (69 m shoreward from the tip of the jetty), was tracked from 9 August through 26 September 1992, (Table 1). A total of 74.0 hours was expended tracking T5801 (Fig. 3). This turtle ranged 366 m shoreward from the tip of the south jetty on the south side, spending 71% of its time between the 46 - 91 m markers (Fig. 11).

T0000, captured on 8 August 1992, on the south side of the south jetty (69 m shoreward from the tip of the jetty) was tracked intermittently from 9 August through 17 September 1992, (Table 1). A total of 2.8 hours was expended tracking T0000 (Fig. 3). This turtle moved south along Boca Chica Beach the day it was released and did not return to the study site for 9 days.

T0000 ranged approximately 366 m shoreward of the tip of the south jetty on the south side, spending 70% of its time between the 183 - 274 m markers (Fig. 12). Sea conditions usually curtailed the tracking of T0000. Since T0000 had no radio tag, an estimate of its position was not possible when we were unable to get the tracking vessel to the south side of the south jetty. The turtle also ranged very close to shore at times making it difficult to follow by boat. Therefore information on this animal was minimal and sporadic.

T5501, captured on 9 August 1992, on the south side of the south jetty (46 m marker), was tracked from 10 August through 23 August 1992, (Table 1). A total of 10.8 hours was expended tracking T5501 (Fig. 3). Following its release, T5501 moved to the north side of the north jetty where it remained until leaving the study area. It ranged approximately 183 m shoreward of the tip of the south jetty, spending 77% of its time between the 46 and 137 m markers (Fig. 13). This turtle left the jetties on the 16th day of tracking and is not known to have returned to the study area.

Submergence and Surface Behavior

Overall, surface times were inflated since sea turtles can swim near the surface with the 40-cm antenna on the radio tag penetrating the air-water interface. Therefore, it follows that submerged times were underestimated.

Submergence times ranged from 1 sec to 40 min for the 9 sea turtles with radio tags. Overall mean submergence times varied

from 1.9 - 6.1 min between turtles. Surface times ranged from 1.0 sec to 19.1 min. Overall mean surface times varied from 8.5 - 26.5 sec between turtles. The mean length of submergence and surface times, by hour of day, for all turtles was quite variable (Fig. 14).

A detailed breakdown of the submergence times, by turtle, revealed that 74% to 96% of the submergences were < 10 min and 38 to 64% were < 1 min in duration (Fig. 15). This was comparable to data collected by Renaud et al. (1992) where 89% to 99% and 17% to 56% of the turtle submergences fell into the above categories. Submergence patterns were significantly different when data were analyzed by dawn, day, dusk and night (Table 2). For 6 of 7 sea turtles monitored at night, submergence duration was significantly longer than in all other time periods. The number of submergences at night > 10 min, for the same 6 turtles was from 4 to 75% higher when compared to their day activity. Submergences > 5 min in duration were followed by several short surface and submergence periods of less than 1 minute in duration. Ninety-nine percent of all sea turtle submergences were less than 20 min.

Surface times were grouped into periods of $\leq$ 5 sec, $\leq$ 15 sec and > 15 sec. An analysis of the surface times, by turtle, revealed that 41% to 77% of the surfacings were $\leq$ 5 sec and 67 to 92% were $\leq$ 15 sec in duration (Fig. 15). Surface patterns were significantly different when data were analyzed by dawn, day, dusk and night (Table 3). The mean duration for surface interval

was highest at night for all turtles and significantly higher in 6 of 7 instances. There were 21 to 78% more surfacings > 15 sec at night than during day. Increased duration of surfacings at night coincided with increased mean submergence times and fewer submergences at night. Increased surface intervals at night may also be related to the lack of visual stimuli which may prompt turtles to submerge sooner during the day.

Submergence times ranged from 1 sec to 24.3 min for T5413. All surface times were < 2.3 min except at night when they reached 12.3 min. Mean surface and submergence times during the day were 5.2 sec and 3.9 min respectively (Tables 2 and 3). Mean surface (46.6 sec) and submergence (2.9 min) times were significantly different at night compared to the day (Fig. 3). Mean submergence time at dusk was significantly shorter than at all other time periods. No clear cut differences in dawn submergence behavior was evident with respect to day or night (Table 2). The TDR placed on T5413 remained attached to the turtle for 2 days. No radio or sonic signals from the floating tag were ever heard, and the tag was never recovered.

Submergence times ranged from 1 sec to 21.4 min for T5341. All surface times were < 4.1 min except at dusk when they reached 10.5 min. Mean surface and submergence times during the day were 14.7 sec and 2.8 min respectively (Tables 2 and 3). Mean submergence (5.3 min) time was significantly higher at night compared to dusk. There were no significant differences in surface times. Differences were mitigated by small sample sizes.

Testing of the TDR placed on T5341 established that it had a mean error of -1.12 m and a standard deviation of 0.122 m. Therefore, depth information from the TDR was increased by 1.12 m prior to the analysis of 79 hr and 10 min of data.

Immediately after release (1250) T5341 moved to deeper water and began a series of increasingly deep dives. Initial dives were to 2 m or less. Dive depth generally increased for the next hour, with maximum depths of about 16 m. A period of shallower dives ($\leq$ 11 m) followed for approximately 15 min, which was itself followed by a short sequence of dives > 15 m. At about 1415 dive depth decreased sharply to < 2 m. The turtle was observed moving into a shallow cove at this time, where it stayed for the rest of the day's telemetry period.

An overall frequency distribution (Table 4) showed that the 1-2 m interval was by far the most utilized depth, with 63.3% of all readings. The next two preferred depth zones were 2-3 m (15.1%) and 0-1 m (6.5%) . Frequency declined as depth increased until 10-11 m. An increase in readings occurred at 10-11 m, 12-13 m, and 14-16 m. Still, all readings greater than 10 m only represented 4.1% of the total.

Mean depths for each time period varied from 1.4 m to 3.2 m (Table 5). Analysis of variance revealed significant differences between all time periods.

When data were separated by day as well as time period, daily differences could be seen. No dives > 2.5 m were recorded on 3 August, resulting in a daily mean depth considerably less

than on the other days. A majority of readings between 0700 and 1400 on 2 August were moderate to deep (> 5 m), reflected in the higher dawn and day mean depths on that day. The greatest dusk mean depth was on 1 August. Night means were relatively uniform. No dive deeper than 3.5 m occurred during this time period.

Deep dive episodes were considered to be any group of dives $\geq$ 10 m not separated by more than 30 min. A total of 6 deep dive episodes were recorded. Moderate dive episodes (5-10 m) were associated with 3 of the deep dive episodes. Deep dive episodes occurred during all time periods except night, while moderate dive episodes were recorded during dawn and day.

Submergence times ranged from 2 sec to 33.0 min for T4101. All surface times were < 1.1 min except during the day when they reached 3.3 min. Mean surface and submergence times during the day were 11.8 sec and 5.5 min respectively (Tables 2 and 3). Mean surface (56.4 sec) and submergence (22.9 min) times at night were significantly higher than all other mean surface times. This behavioral change occurred shortly after dusk.

Submergence times ranged from 1 sec to 25.4 min for T4598. Surface times were < 1.0 min during the day but reached 3.0 to 4.0 min for all other time periods. Mean surface and submergence times during the day were 4.9 sec and 1.7 min respectively (Tables 2 and 3). Mean surface times were significantly higher at night and dusk compared to day and dawn. Dawn surface mean also was significantly higher than day. Submergence times were significantly different for all time

periods except dawn and day, with the lowest (1.1 min) at dusk and the highest (3.1) at night.

Submergence times ranged from 1 sec to 31.2 min for T5601. Surface times reached at least 12 min during all periods of the day. Mean surface and submergence times during the day were 18.8 sec and 1.7 min respectively (Tables 2 and 3). Mean surface (35.2 sec) and submergence (2.8 min) times were significantly higher at night, compared to day. Mean submergence time was significantly higher at night, and significantly lower at dusk, than all other periods.

Submergence times ranged from 1 sec to 39.8 min for T5200. Surface times during dawn did not exceed 32.0 sec but reached 68.0 sec for all other time periods sampled. Mean surface and submergence times during the day were 11.1 sec and 5.3 min respectively (Tables 2 and 3). Mean submergence (2.1 min) time was significantly lower at dawn compared to day and dusk. There were no significant differences in surface times. Night data were not available.

Submergence times ranged from 1 sec to 25.8 min for T4698 with no significant differences between dawn, day and dusk when this turtle was at the jetty habitat. Data were not available for night. Mean surface times ranged from 1 to 167 sec with no statistically detectable differences in the above mentioned categories. When T4698 was in South Bay, the surface and submerged times ranged from 1 - 167 sec (surface) and 1 sec to 35.8 min (submergence) (Tables 2 and 3). Mean surface and

submergence times were significantly higher at night vs all other time periods, and higher at dawn compared to dusk and day.

Submergence times ranged from 1 sec to 37.8 min for T5801. Maximum surface times were between 63 and 94 sec during all time periods, however mean values ranged from 6.0 to 12.8 seconds Tables 2 and 3). Mean surface and submergence times during the day were 4.7 sec and 2.9 min respectively. Mean surface (19.8 sec) and submergence times (4.3 min) were significantly higher at night compared to all other time periods. Mean surface time also was significantly higher at dusk than at dawn or day.

Submergence durations ranged from 1 sec to 38.1 min for T5501, and from 1 to 62 sec for surface times. Mean submergence was 3.5 min for dawn and 5.2 min for day. Mean surface time was 5.8 sec for dawn and 6 sec for day. Means were not significantly different. No data were collected during dusk or night.

Environmental Data

Water temperatures and salinities near the jetties ranged from 24 to 31^{o}C and 27 to 40 ppt (Fig. 16) and were within ranges recorded during the previous 10 years. Landry et al. (1993) present additional temperature and salinity data for this study.

Habitat Characterization

Two habitats characterized during this study were the jetty and BSC. The jetty habitat extends from the intertidal zone on the rocks, out 25 m to an area of scattered boulders approximately 8 m in depth. This area offers refuge for sea

turtles and substrate for epifloral and epifaunal food sources. Barnacles (Balanus sp.), 3 algal species (Ulva fasciata, Podina vickersiae, and Bryocladia thysigera), and sea urchins (Arbacia punctulata) were the most abundant organisms at the jetties (Landry et al., 1992). The BSC habitat harbors populations of portunid crabs, shrimp, fish and squid. Detailed listings of all flora and fauna found in the BSC and jetty habitats are provided in Landry et al. (1993).

DISCUSSION

Habitat Utilization

Seagrass beds are the most extensive habitat in the Laguna Madre, followed by vegetated areas in which seagrass is not the dominant plant species, non vegetated flats and channels including the ICWW. Brazos-Santiago Pass links the Laguna Madre and offshore areas. Brazos-Santiago Pass can be subdivided into 4 regions: 1) the channel, 2) Dolphin and Barracuda Coves, 3) unvegetated flats adjacent to the channel and 4) the jetty habitat, i.e. the submerged portion of the jetty and the area extending 15 m out from the jetty rocks. Juvenile green sea turtles, more numerous in the jetty habitat, were not distributed equally over these areas in relation to the extent of each habitat type (Renaud et al. 1992; Landry et al. 1992). This suggests that jetties provide a high quality habitat for juvenile green sea turtles and that these sea turtles may congregate there for cover and food. Numerous sightings of sea turtles during the study (Landry et al. 1993 and Fig. 17), supported the hypothesis that the jetty is a preferred habitat of juvenile green sea turtles.

Home Range

Turtles exhibited home ranges along the jetties from 400 to 1350 m. Core areas during dawn, day, dusk and night were usually < 100 m in extent except where bi- or trimodal cores were occurred. In the latter case, the modes, < 100 m in extent, were

up to 250 m apart. All turtle home ranges included sheltered areas. Turtles moved if adverse water conditions caused by weather altered the serenity of a core area. In most cases, the distribution of individual sea turtles at night was more restricted than during the day.

Feeding may account for the limited movement of the sea turtles tracked in this study. Turtles were seen feeding on algal growth along the jetties especially at dusk. All of the tracked green sea turtles were in habitats where algae was abundant or in close proximity to habitats with algal food sources.

The TDR evidence indicates that: 1) Dive activity varies by day, 2) Deep diving activity may be restricted to the period from dawn to dusk, 3) Channel use is very limited, 4) Release behavior indicates that the channel may be used as escape cover when turtles are disturbed, and 5) Timing of deep dive episodes indicates that the channel was not used during rest periods. Green turtles in the channel during dredging should be active and more able to escape.

The turtles tracked on the north side of the south jetty had a tendency to move into Barracuda Cove at night. This was especially evident in T5413, whose daily movements extended to the outer end of the jetty, and whose night core area was deep in the cove along the jetty. T4101, on the south side of the north jetty, also showed greater shoreward movement at night than at any other time. The reason for this movement is unknown. Longer

surface and submergence times and more restricted movements indicate that night may be used mostly for resting. If so, then the turtles may use the more sheltered environment of the cove for resting at night, while utilizing a broader stretch of the jetty for daytime foraging activities.

Submerged Behavior

Two types of submerged behavior of the sea turtles were noted, foraging and resting. Active periods of foraging and feeding (submergence < 5 min) occurred mostly during dusk and dawn. These observations were reflected in sea turtle movements adjacent to the jetties. Resting behavior (submergence $\geq$ 10 min) was observed at night and minimally during the afternoon. Little or no movement was noted for sea turtles monitored at night.

CONCLUSIONS

The utilization of the BSC by juvenile green sea turtles was rarely observed. Transient occurrence in the BSC was occasioned by green sea turtles crossing the channel from one jetty to another or using the channel as passageways to enter the Laguna Madre. Only during these times (< 0.3% in our study) would they be susceptible to hopper dredging. Our tracking study suggests juvenile green sea turtles in the Brazos-Santiago Pass area are not significantly threatened with respect to biannual hopper dredging.

The study has expanded our knowledge regarding home range behaviors and life history information of juvenile green sea turtles in the vicinity of South Padre Island, Tx. These conclusions can be tentatively extended for juvenile green sea turtles in other areas, but should not be extended to other sea turtle species. This type of tracking information needs to be collected on other sea turtles to establish how their behaviors will vary.

ACKNOWLEDGEMENTS

We would like to acknowledge several organizations and their personnel for assistance in making this work possible: U. S. Army Corps of Engineers (Galveston and New Orleans Districts) for funding the research, Texas A&M University for capturing the sea turtles and characterizing habitats in the lower Laguna Madre, University of Texas Pan American Coastal Studies Laboratory for making their facility available to hold sea turtles and the U.S. Coast Guard Station at South Padre Island for use of their base to store our tracking vessel.

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Table 1. Capture/release dates, locations, measurements and tagging information for 10 green sea turtles radio tracked near South Padre Island, Texas.

Turtle	Capture* Date/Location	Release* Date/Location	Lengths(cm)/ Weights(kg)	Flipper Tag Numbers	Radio Freq/ Sonic Freq (with code)	Last Contact
T5413	28 Jul 1992 NS/SJ 868 m	31 Jul 1992 NS/SJ 868 m	SL - 47.9 SW - 39.4 CL - 51.5 CW - 45.2 WT - 14.8	QQC765	165.413 Mhz 30.0 Khz (no code) **	26 Sep 1992 Visual/Sonic
T5341	30 Jul 1992 NS/SJ 914 m	1 Aug 1992 NS/SJ 914 m	SL - 44.7 SW - 35.8 CL - 47.6 CW - 43.0 WT - 11.5	QQC750 QQC751	165.341 Mhz 31.0 Khz (3-3-3-3) **	25 Sep 1992 Sonic
T4101	30 Jul 1992 SS/NJ 365 m	1 Aug 1992 SS/NJ 365 m	SL - 30.1 SW - 24.3 CL - 31.6 CW - 27.6 WT - 3.1	QQC766 QQC771	164.101 Mhz 34.0 Khz (5-5-5-5)	26 Sep 1992 Visual/Sonic
T5601	29 Jul 1992 NS/SJ 1005 m	1 Aug 1992 NS/SJ 1005 m	SL - 29.1 SW - 22.6 CL - 31.0 CW - 25.5 WT - 2.7	QQC734 QQC735	165.601 Mhz 35.0 Khz (5-2-5-2)	15 Oct 1992 Visual/Sonic Radio
T4598	29 Jul 1992 NS/SJ 868 m	1 Aug 1992 NS/SJ 868 m	SL - 29.2 SW - 22.7 CL - 30.8 CW - 25.5 WT - 2.6	QQC740 QQC741	164.598 Mhz 37.0 Khz (2-2-2-2)	26 Sep 1991 Radio

*All capture/release locations are approximate distances from tip of jetty; SS = South side; NS = North side; SJ = South jetty; NJ = North jetty.
**Turtles also had detachable trailing tag.

Table 1 (cont.). Capture/release dates, locations, measurements and tagging information for ten green sea turtles radio tracked near South Padre Island, Texas.

Turtle	Capture* Date/Location	Release* Date/Location	Lengths(cm)/ Weights(kg)	Flipper Tag Numbers	Radio Freq/ Sonic Freq (with code)	Last Contact
T5200	31 Jul 1992 NS/SJ 137 m	2 Aug 1992 NS/SJ 137 m	SL - 31.5 SW - 24.9 CL - 33.2 CW - 29.5 WT - 3.6	QQC767	165.200 Mhz 32.0 Khz (no code)	26 Sep 1992 Visual/Sonic
T4698	4 Aug 1992 SS/NJ 731 m	6 Aug 1992 SS/NJ 731 m	SL - 33.3 SW - 26.7 CL - 35.2 CW - 29.8 WT - 3.9	QQC768	164.698 Mhz 31.8 Khz (4-2-4-2)	26 Sep 1992 Visual/Sonic
T5801	8 Aug 1992 SS/SJ 68 m	9 Aug 1992 SS/SJ 68 m	SL - 31.5 SW - 26.0 CL - 32.4 CW - 29.8 WT - 3.4	QQC770	165.801 Mhz 31.9 Khz (no code)	26 Sep 1992 Visual/Sonic Radio
T0000	8 Aug 1992 SS/SJ 68 m	9 Aug 1992 SS/SJ 68 m	SL - 26.6 SW - 22.0 CL - 28.3 CW - 23.9 WT - 2.0	QQC769	No radio 32.2 Khz (2-3-2-3)	17 Sep 1992 Sonic
T5501	8 Aug 1992 SS/SJ 45 m	10 Aug 1992 SS/SJ 45 m	SL - 33.0 SW - 25.4 CL - 35.3 CW - ---- WT - 4.1	NNZ641	165.501 Mhz 33.0 Khz (3-4-3-4)	23 Aug 1992 Visual/Sonic

*All capture/release locations are approximate distances from tip of jetty; SS = South side; NS = North side; SJ = South jetty; NJ = North jetty.

Table 2. Comparison of submergence duration in min (Tukey-Kramer) by dawn, day, dusk and night for sea turtles with radio tags. Mean durations of submergence, are significantly different from each other if time periods are not connected by horizontal underlines.

Turtle	Periods of the Day			
4101	Day	Dawn	Dusk	Night
	5.5	6.1	7.4	22.9
4598	Dusk	Day	Dawn	Night
	1.1	1.7	1.8	3.1
4698 at jetty	Dawn	Day	Dusk	
	2.0	2.4	3.1	
4698 in South Bay	Dusk	Day	Dawn	Night
	1.9	2.6	3.7	10.2
5200	Dawn	Day	Dusk	
	2.1	5.3	8.3	
5341	Dusk	Dawn	Day	Night
	2.4	2.6	2.8	5.3
5413	Dusk	Night	Dawn	Day
	1.0	2.9	3.6	3.9
5501	Dawn	Day		
	3.5	5.2		
5601	Dusk	Day	Dawn	Night
	1.0	1.7	1.8	2.8
5801	Dusk	Day	Dawn	Night
	2.8	2.9	2.9	4.3

Table 3. Comparison of surface duration in sec (Tukey-Kramer) by dawn, day, dusk and night for sea turtles with radio tags. Mean surface intervals, are significantly different from each other if time periods are not connected by horizontal underlines.

Turtle	Periods of the Day			
4101	Day	Dawn	Dusk	Night
	11.8	13.1	16.0	56.4
4598	Day	Dawn	Dusk	Night
	4.9	12.8	19.4	19.8
4698	Day	Dusk	Dawn	
at jetty	9.2	11.5	13.7	
4698	Day	Dusk	Dawn	Night
in South Bay	2.1	2.1	6.7	38.8
5200	Dawn	Day	Dusk	
	6.6	11.1	15.1	
5341	Dawn	Day	Dusk	Night
	10.1	14.7	20.9	25.5
5413	Day	Dusk	Dawn	Night
	5.2	11.5	12.5	46.6
5501	Dawn	Day		
	5.8	6.0		
5601	Day	Dusk	Dawn	Night
	18.8	23.8	29.4	35.2
5801	Day	Dawn	Dusk	Night
	4.7	6.0	9.0	12.8

Table 4. Frequency distribution of depth readings grouped in 1 m intervals for T5341. Information was obtained from a time-depth recorder set to record at 20 second intervals. Data from the first 2 hours after release were not included.

Depth Interval	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Surface	165	1.2	165	1.2
0-1	902	6.5	1067	7.7
1-2	8768	63.3	9835	71.0
2-3	2093	15.1	11928	86.1
3-4	588	4.2	12516	90.3
4-5	197	1.4	12713	91.7
5-6	138	1.0	12851	92.7
6-7	188	1.4	13039	94.1
7-8	115	0.8	13154	94.9
8-9	83	0.6	13237	95.5
9-10	50	0.4	13287	95.9
10-11	74	0.5	13361	96.4
11-12	57	0.4	13418	96.8
12-13	178	1.3	13596	98.1
13-14	31	0.2	13627	98.3
14-15	119	0.9	13746	99.2
15-16	102	0.7	13848	99.9
16-17	12	0.1	13860	100.0

Table 5. Mean depths and standard deviations by time period and date for T5341. Information was obtained from a time-depth recorder set to record at 20 second intervals. Data from the first 2 hours after release were not included.

Time Period	Date	N	Minimum	Maximum	Mean	Std Dev	Std Error
Dawn	Aug 2	720	0.500	16.700	4.255	4.538	0.169
	Aug 3	720	0	1.900	1.482	0.384	0.014
	Aug 4	720	0.900	5.100	2.178	1.004	0.037
Day	Aug 1	360	0.100	6.900	2.004	1.077	0.057
	Aug 2	1440	0	16.500	4.924	4.320	0.114
	Aug 3	1440	0	2.100	1.550	0.354	0.009
	Aug 4	1440	0.300	14.700	3.372	2.966	0.078
Dusk	Aug 1	720	0	14.500	4.315	4.397	0.164
	Aug 2	720	0	4.900	1.770	0.896	0.033
	Aug 3	720	0	1.900	1.395	0.392	0.015
	Aug 4	540	0.500	3.100	2.093	0.628	0.027
Night	Aug 1	540	0.900	3.500	1.445	0.550	0.024
	Aug 2	1440	0.300	3.500	1.533	0.684	0.018
	Aug 3	1440	0	2.500	1.417	0.470	0.012
	Aug 4	900	0	2.100	1.372	0.432	0.014
Date				**Daily Means**			
Aug 1	1620	1620	0	14.500	2.845	3.273	0.081
Aug 2	4320	4320	0	16.700	3.157	3.518	0.054
Aug 3	4319	4319	0	2.500	1.469	0.412	0.006
Aug 4	3600	3600	0	14.700	2.441	2.119	0.035

Table 6. Total range length, core area length, and percent of time spent in core area for ten green sea turtles radio tracked near South Padre Island, Texas. NS=north side, SS=south side, NJ=north jetty, SJ=south jetty.

Turtle	Home Range Size (m)	Core Area Size (m)	Percent of Time in Core Area	Total Hours Tracking w/ Location
0000		366	none	2.8
4101	366	46	76	57.7
4598	732	137	66	57.0
4698	Jetty 595	46	69	13.4
5200	NS,NJ 503	138	61	17.6
	NS,SJ 322	45	98	10.8
	SS,SJ 276	none		2.7
5341	1098	138	72	41.6
5413	1235	183	64	84.6
5501	183	92	77	10.8
5601	960	92	66	71.8
5801	366	45	71	29.0

Table 7. Length of core area by time of day for ten green sea turtles radio tracked near South Padre Island, Texas. A slash (/) indicates a multimodal area. A number between two time periods indicates that the data were combined. NS=north side, SS=south side, NJ=north jetty, SJ=south jetty.

Turtle		Length of Core Area (m)			
		Dawn	Day	Dusk	Night
0000		none	none	none	none
4101		46	46	46	46
4598		46/46	46	46	46/46/46
4698	Jetty	none	46	none	none
5200	NSNJ	none	46	none	none
	NSSJ	none	46	none	none
	SSSJ	none	none	none	none
5341		92	46	46	46
5413		92	138	275	183
5501		none	92	none	none
5601		92	138	92	46
5801		46		none	none

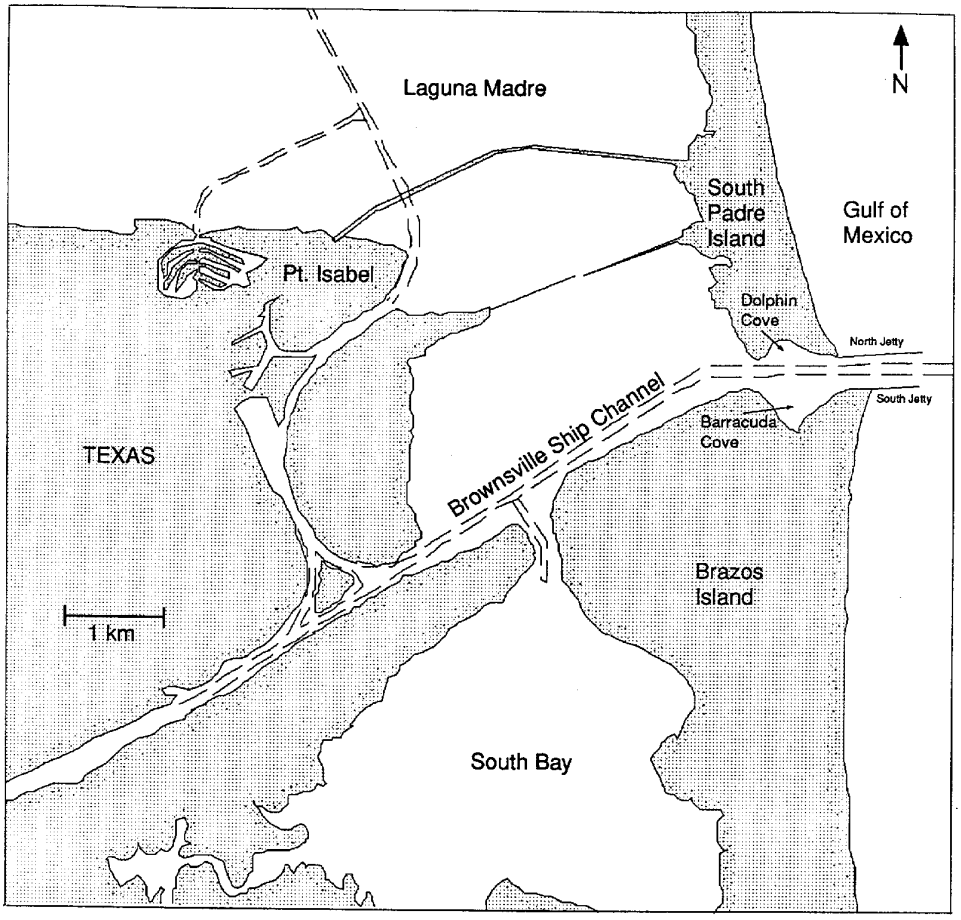


Figure 1. South Padre study area. Dashed lines represent the Intracostal Waterway in the Laguna Madre and Brownsville Ship Channel.

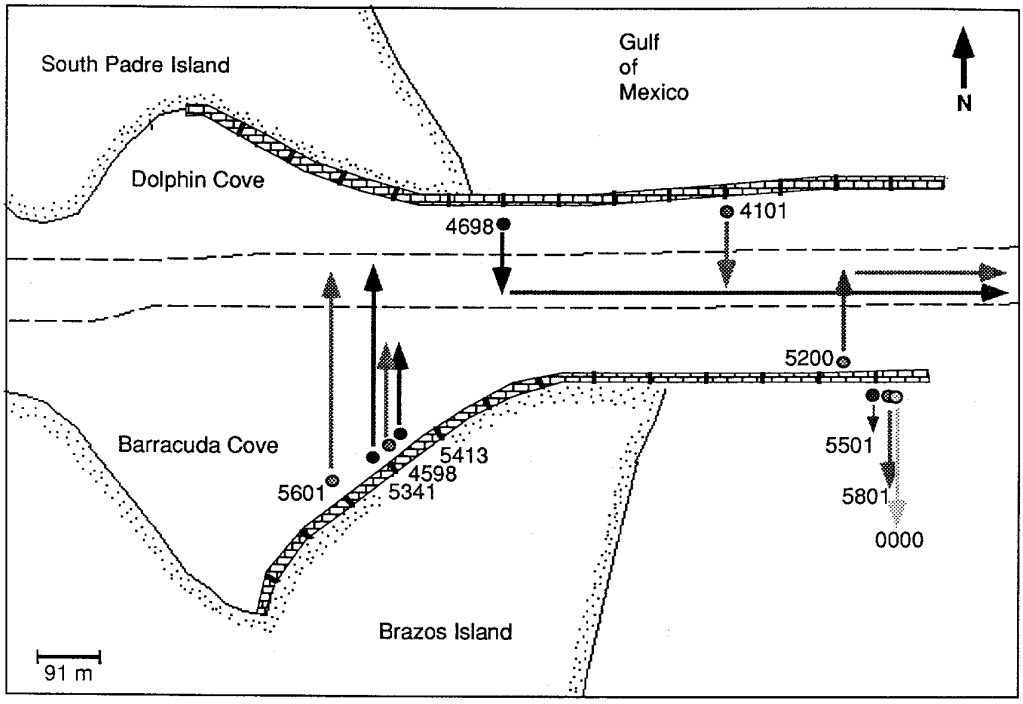


Figure 2. Movements of sea turtles immediately following their release.

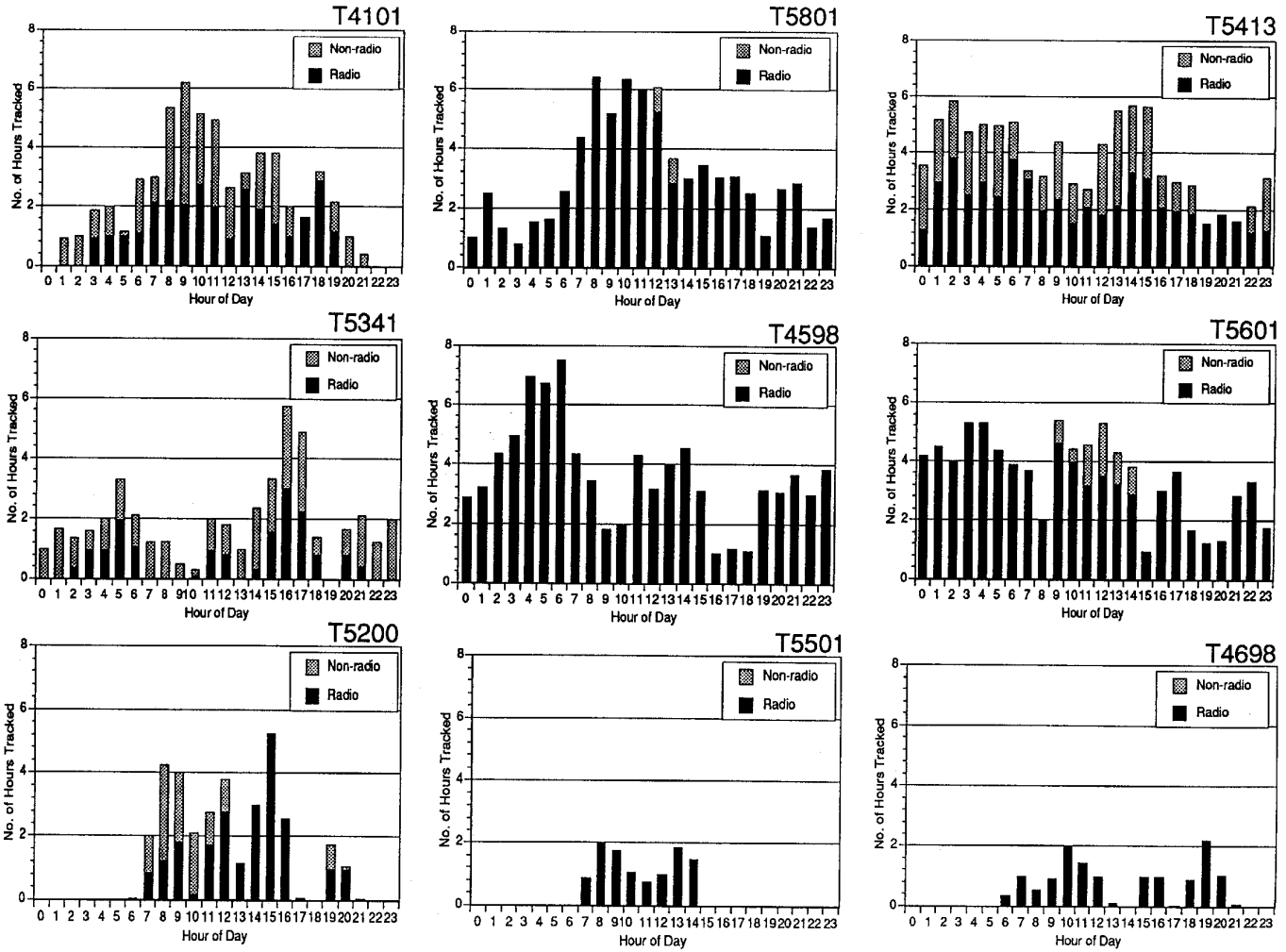


Figure 3. Number of hours tracked, by hour of day, for turtles at the jetty habitat. T0000 was tracked for < 2 hours and was not included in the figure.

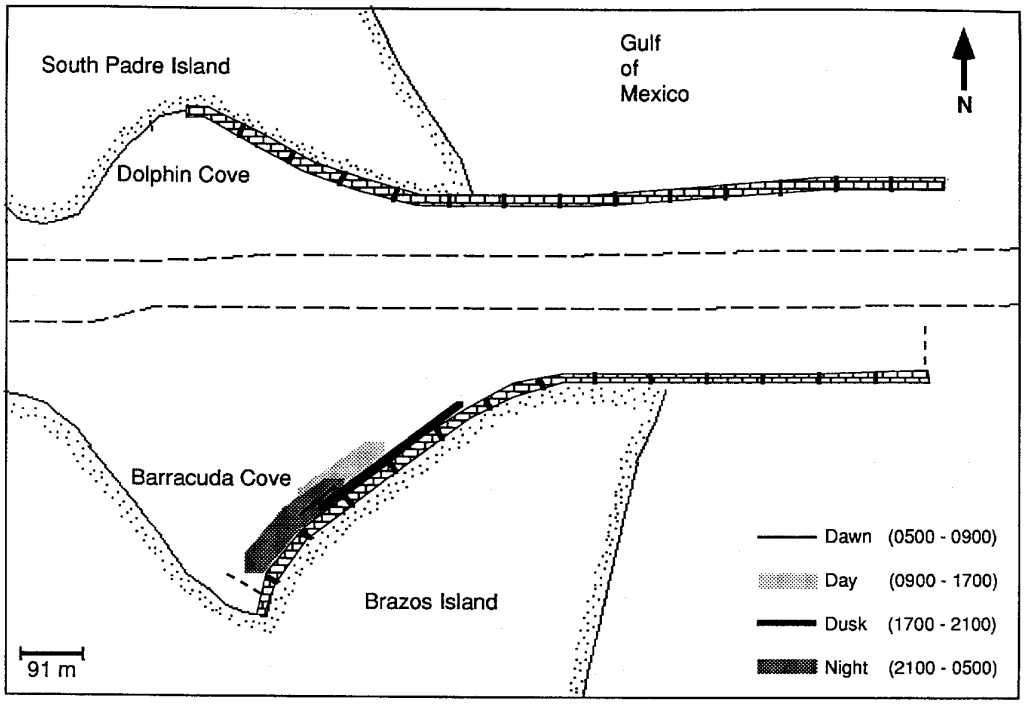


Figure 4. Movement of turtle T5413 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 31 Jul through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

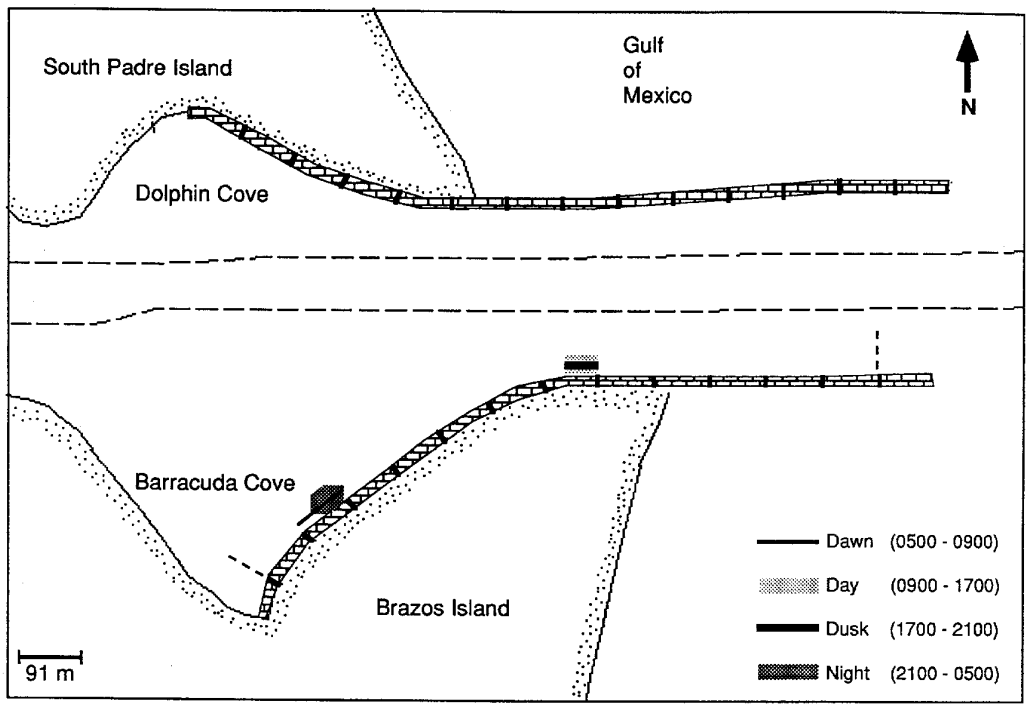


Figure 5. Movement of turtle T5341 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 5 Aug through 25 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

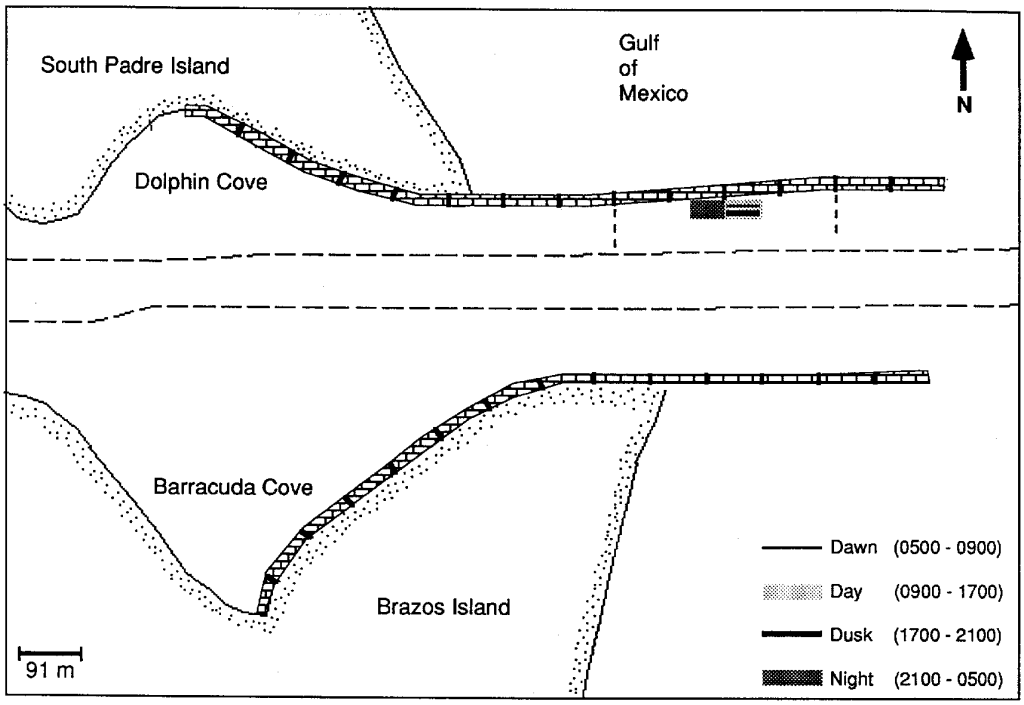


Figure 6. Movement of turtle T4101 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 1 Aug through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

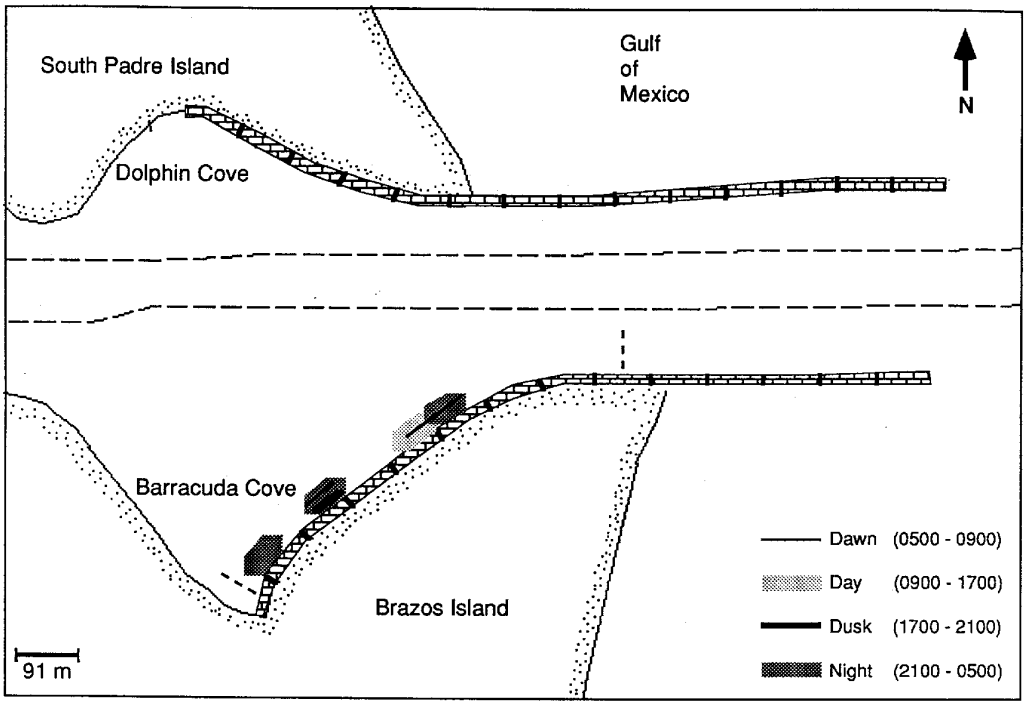


Figure 7. Movement of turtle T4598 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 1 Aug through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

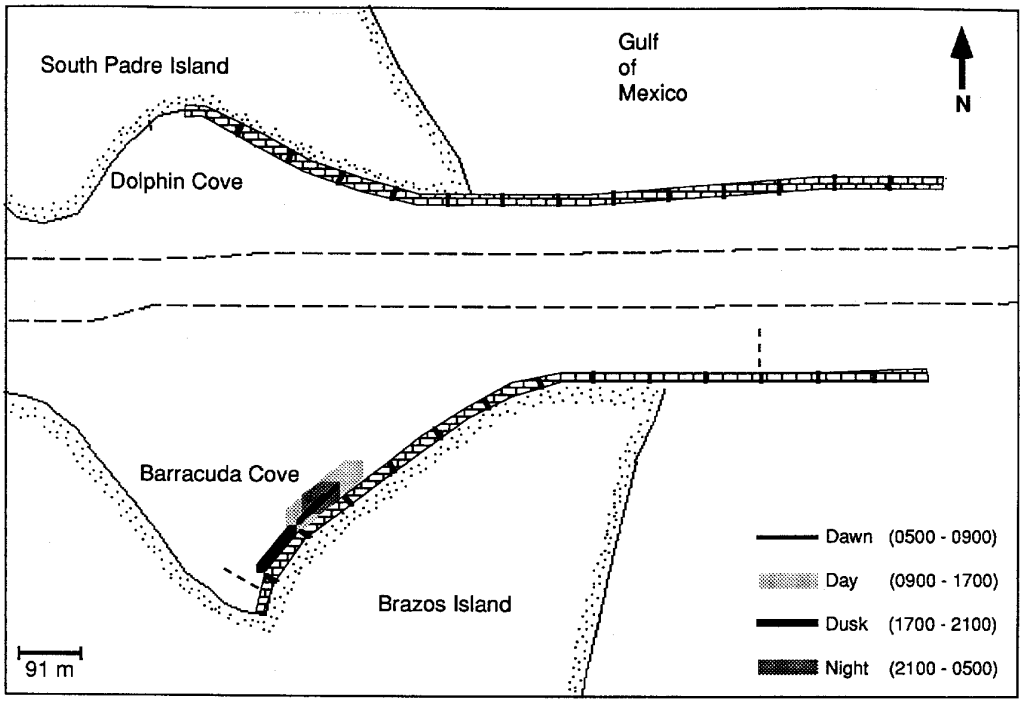


Figure 8. Movement of turtle T5601 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 1 Aug through 15 Oct 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

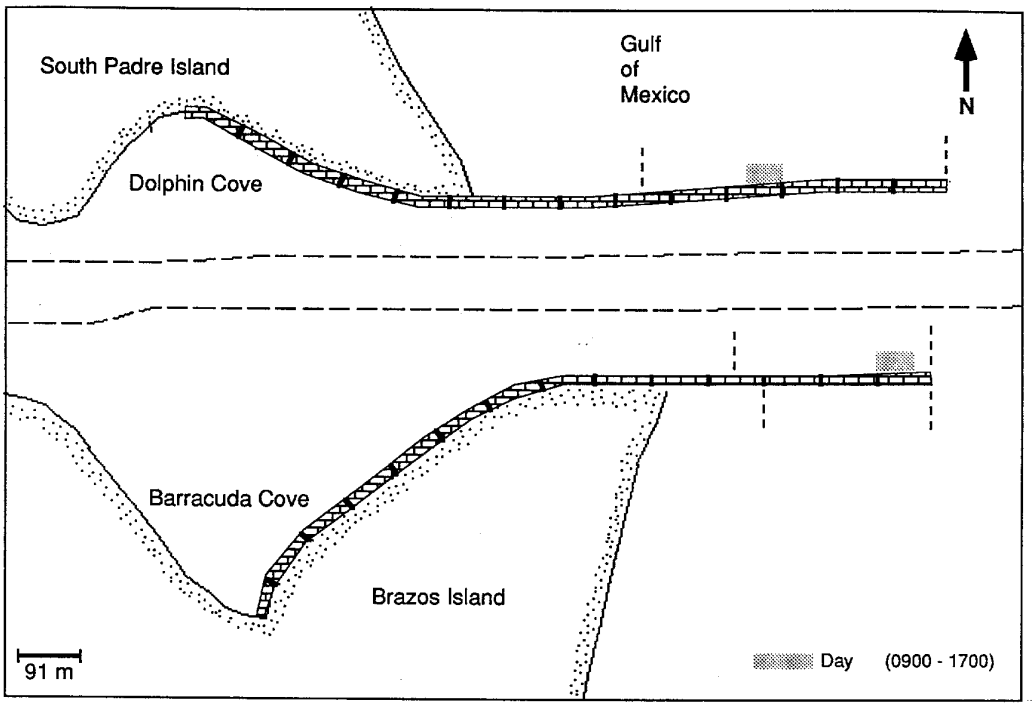


Figure 9. Movement of turtle T5200 during dawn (0500-0900), day (0900-1700) and dusk (1700-2100) from 2 Aug through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

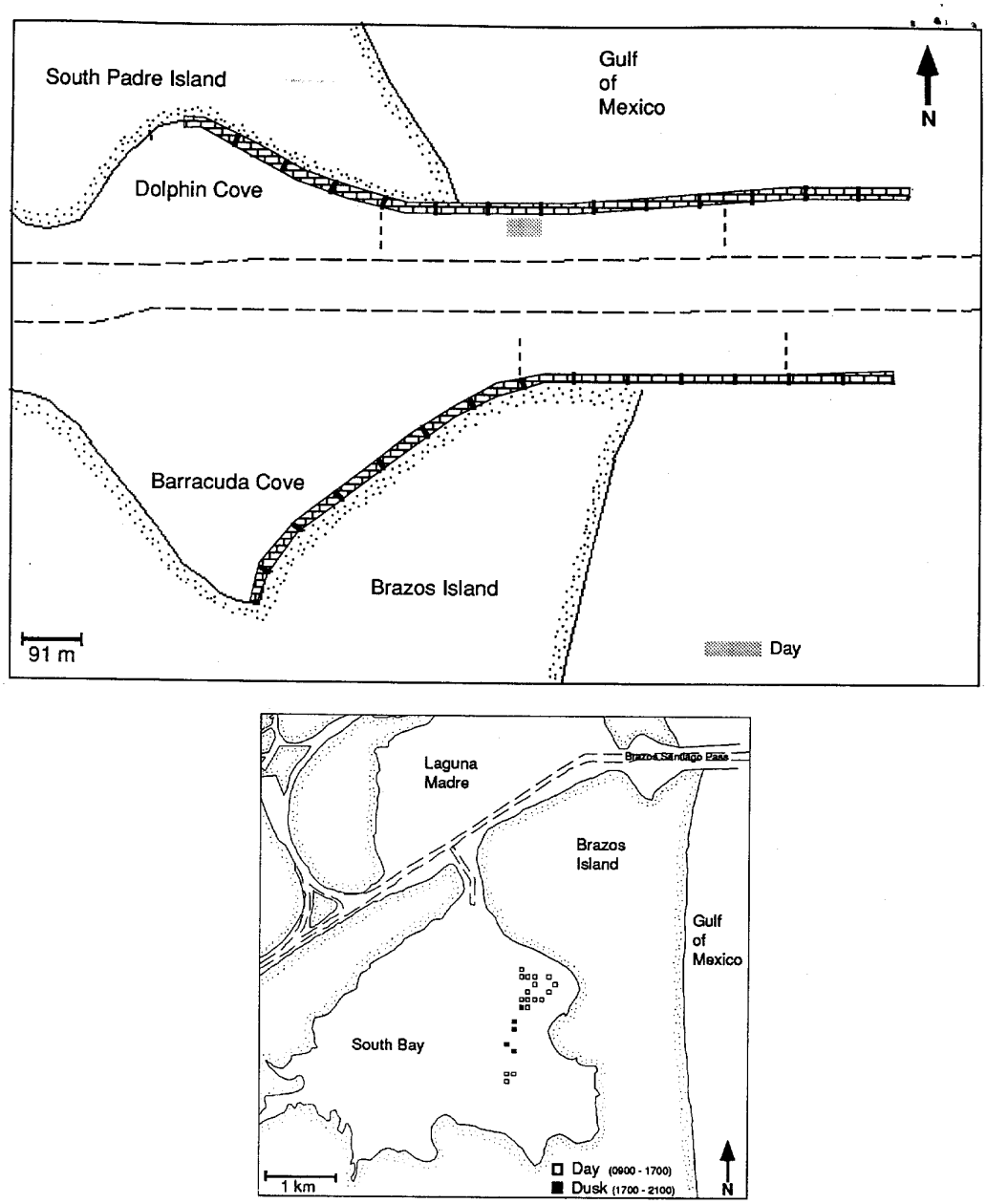


Figure 10. Movement of turtle T4698 during dawn (0500-0900), day (0900-1700) and dusk from 6 Aug through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties. Positions in South Bay during day and dusk are also shown.

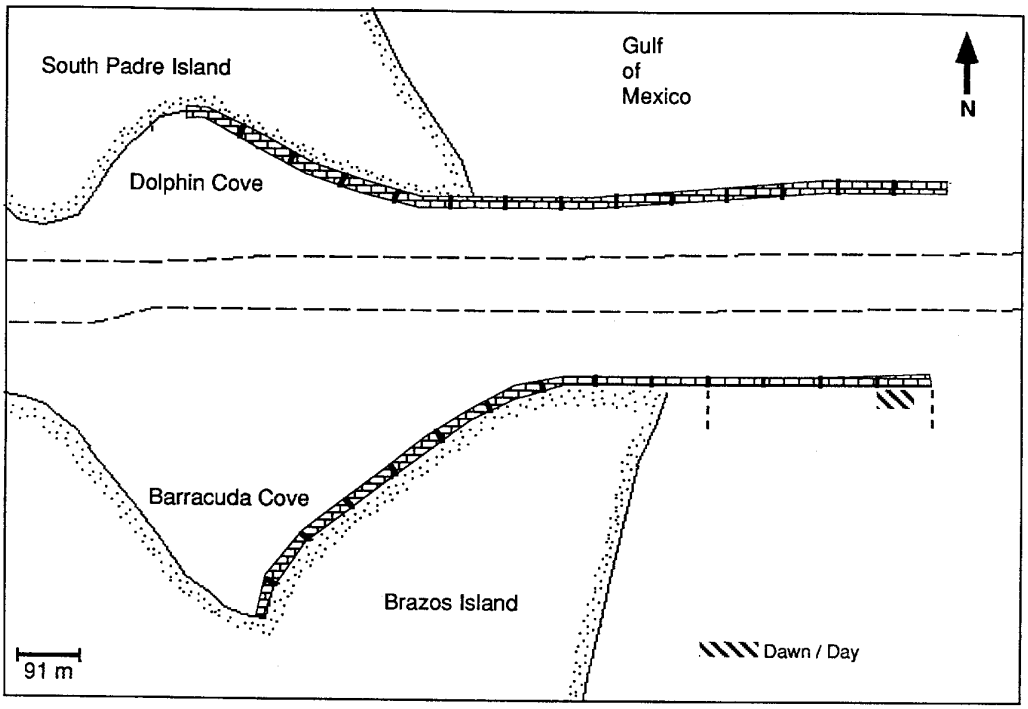


Figure 11. Movement of turtle T5801 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 9 Aug through 26 Sep 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

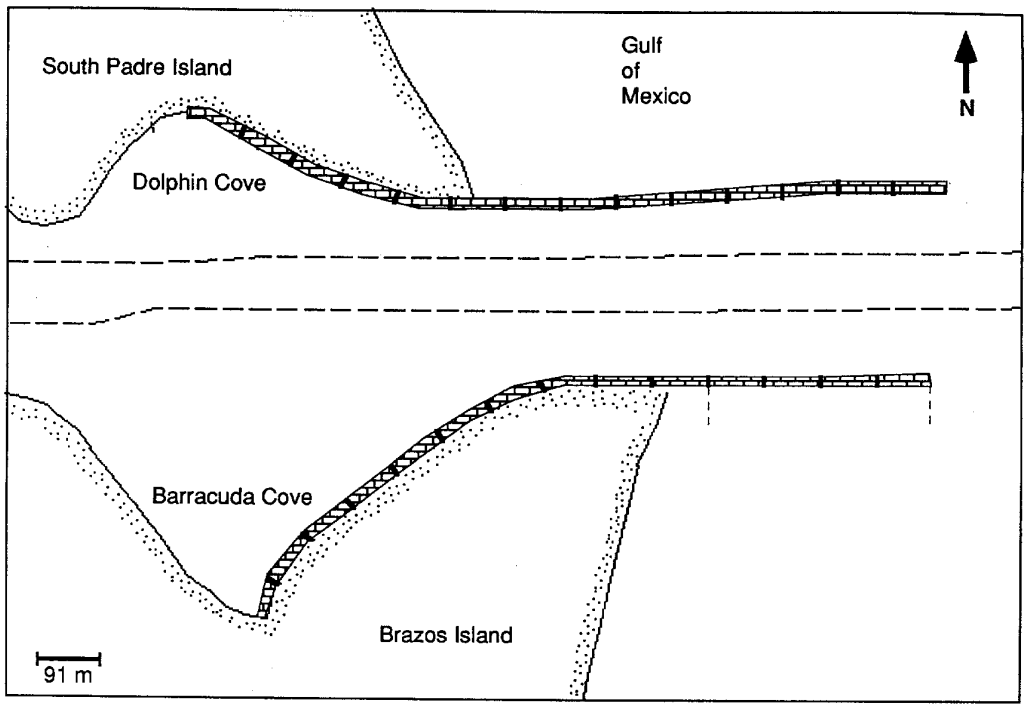


Figure 12. Movement of turtle T0000 from 9 Aug through 17 Sep 1992. Tracking data on this turtle covered < 4 hr and was sporadic. Therefore, only its overall range at the jetties is indicated.

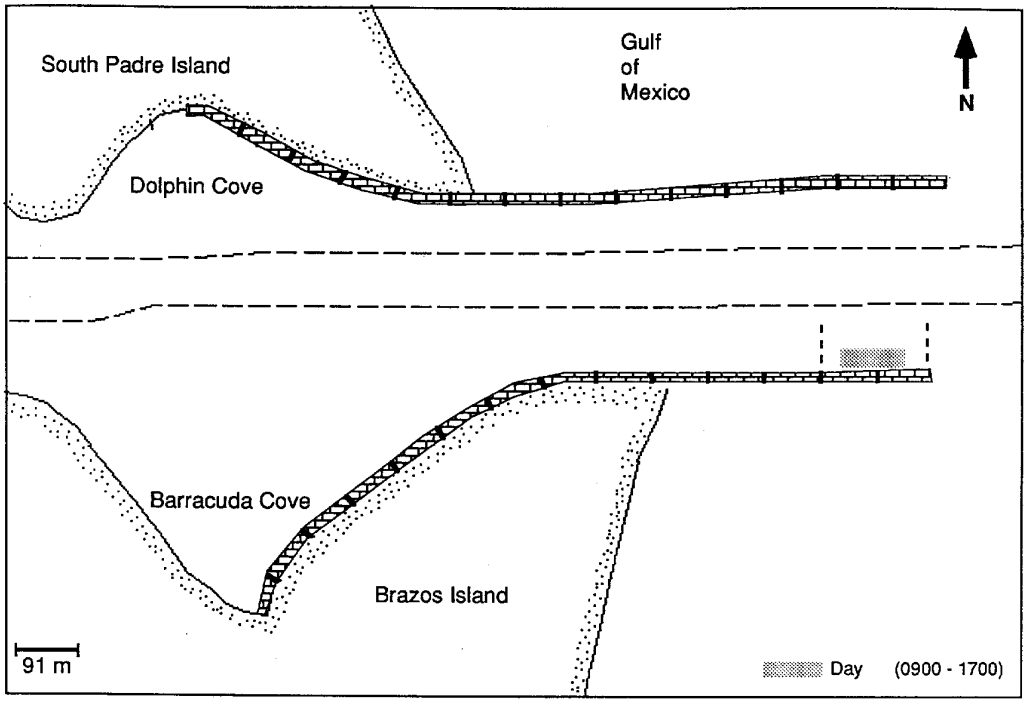
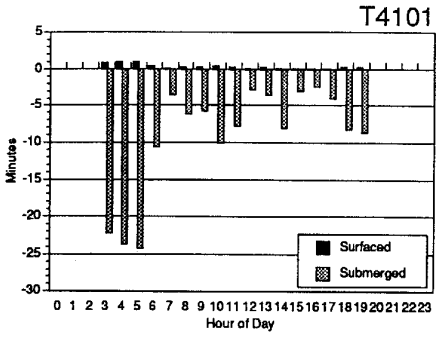
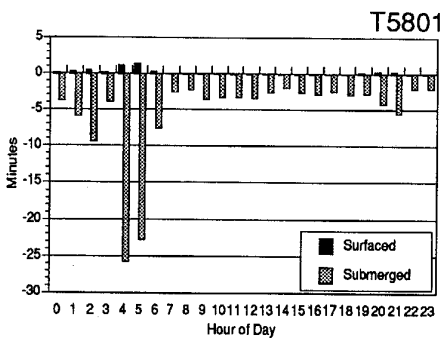
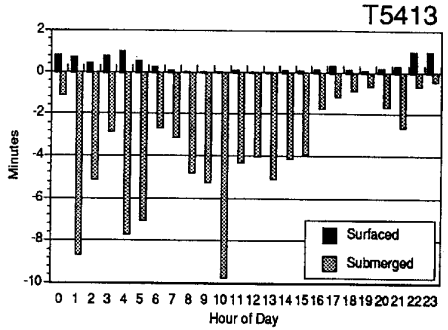


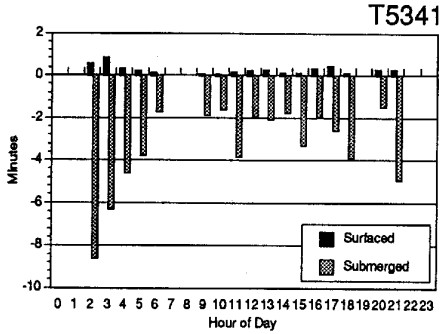
Figure 13. Movement of turtle T5501 during dawn (0500-0900), day (0900-1700), dusk (1700-2100) and night (2100-0500) from 10 Aug through 23 Aug 1992. Core area, region where turtle spent at least 50% of its time, is shaded or barred. Endpoints of the total range of movement are indicated by parallel bars perpendicular to the jetties.

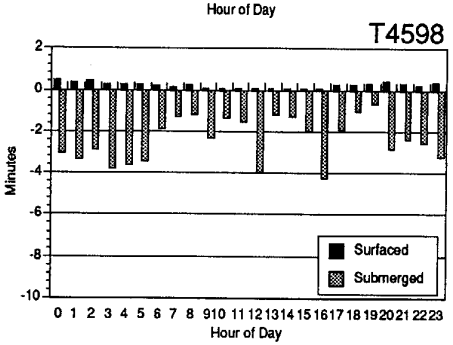
Figure 14. Overall mean surface and submerged times by hour of day for turtles at the jetty habitat. T0000 was not fitted with a radio tag and is not included in the figure. Surface times are slightly increased due to the fact that turtles can swim near the surface with the antenna penetrating the air-water interface, while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives and surface intervals overlapping two one-hour periods were placed in the hour block during which the most time was spent.

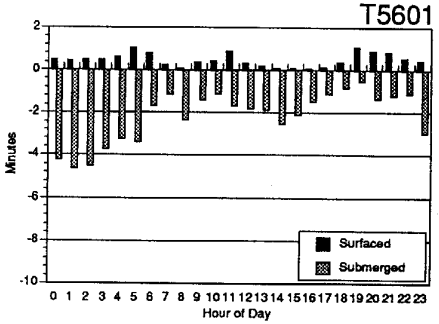

T4101
Minutes
Hour of Day
Surfaced
Submerged

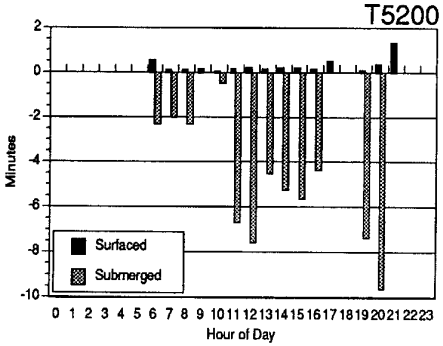

T5801
Minutes
Hour of Day
Surfaced
Submerged

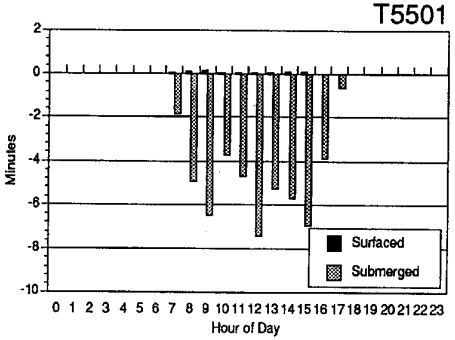

T5413
Minutes
Hour of Day
Surfaced
Submerged

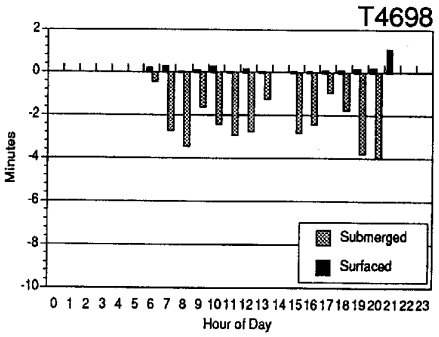

T5341
Minutes
Hour of Day
Surfaced
Submerged


T4598
Minutes
Hour of Day
Surfaced
Submerged


T5601
Minutes
Hour of Day
Surfaced
Submerged


T5200
Minutes
Hour of Day
Surfaced
Submerged


T5501
Minutes
Hour of Day
Surfaced
Submerged


T4698
Minutes
Hour of Day
Submerged
Surfaced

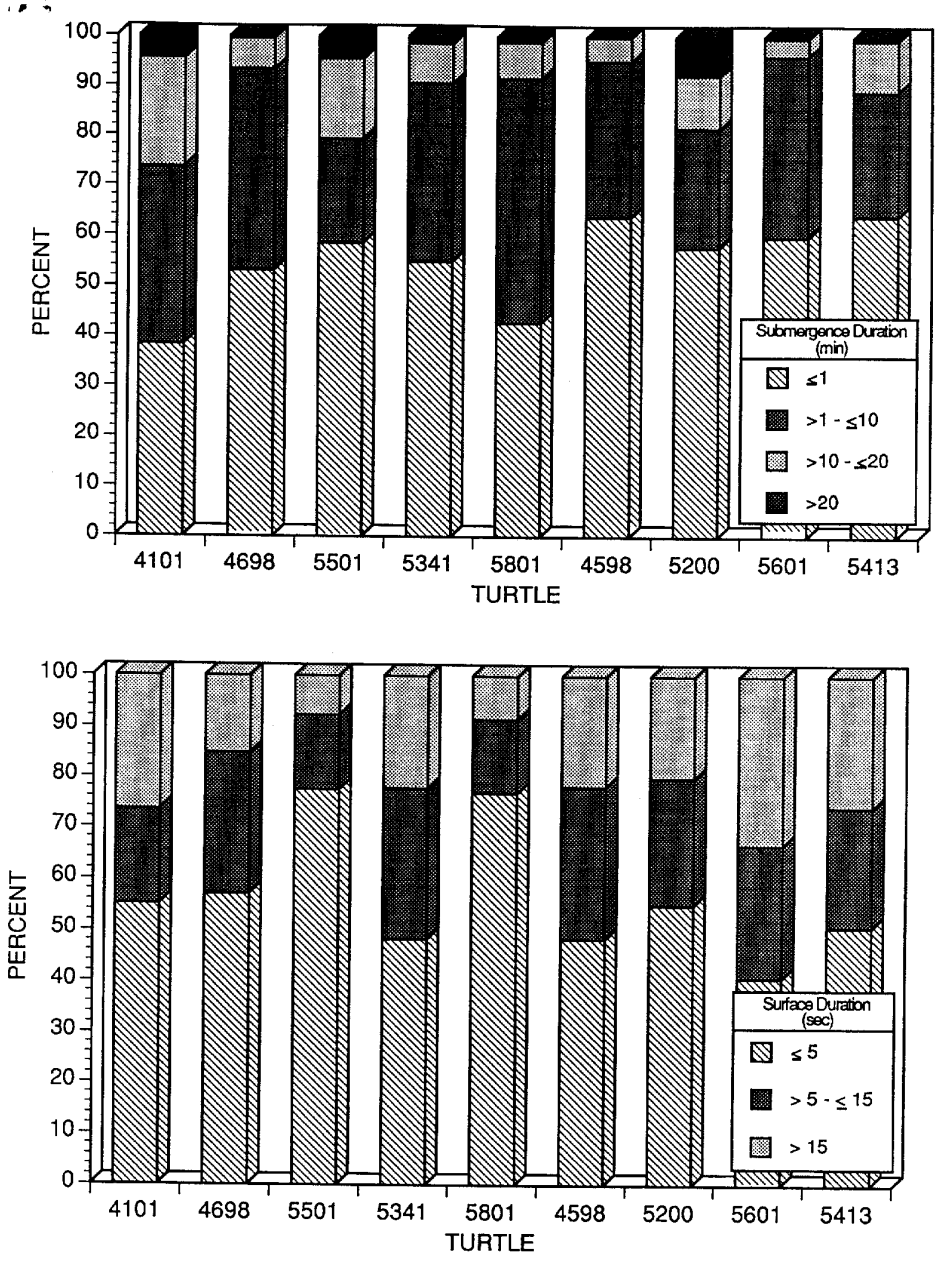


Figure 15. Sea turtle submergence and surface durations by specified time intervals; all times of day combined.

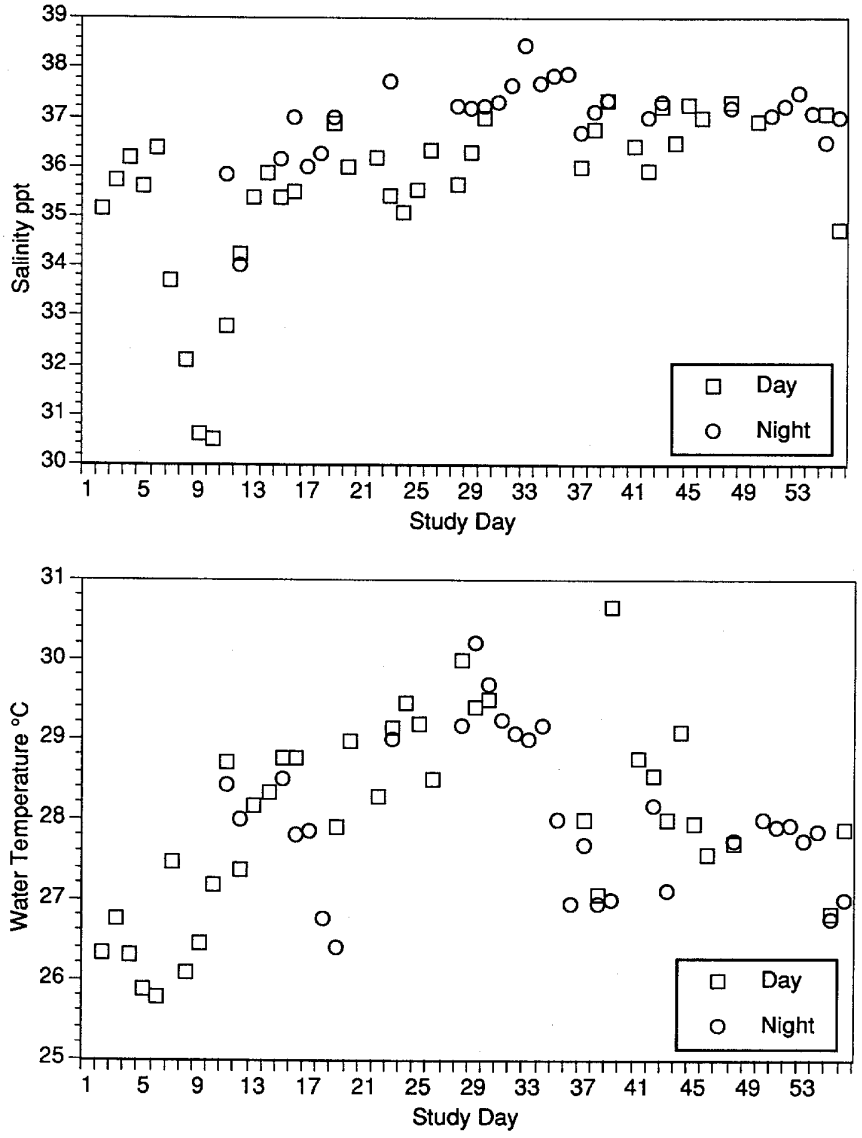


Figure 16. Mean water temperature (°C) and salinity (ppt) by day. Temperature and salinity were recorded at approximately 30 min intervals during normal daily tracking activities. Maximum daily standard error for temperature and salinity were 0.5 °C and 0.8 ppt, respectively.

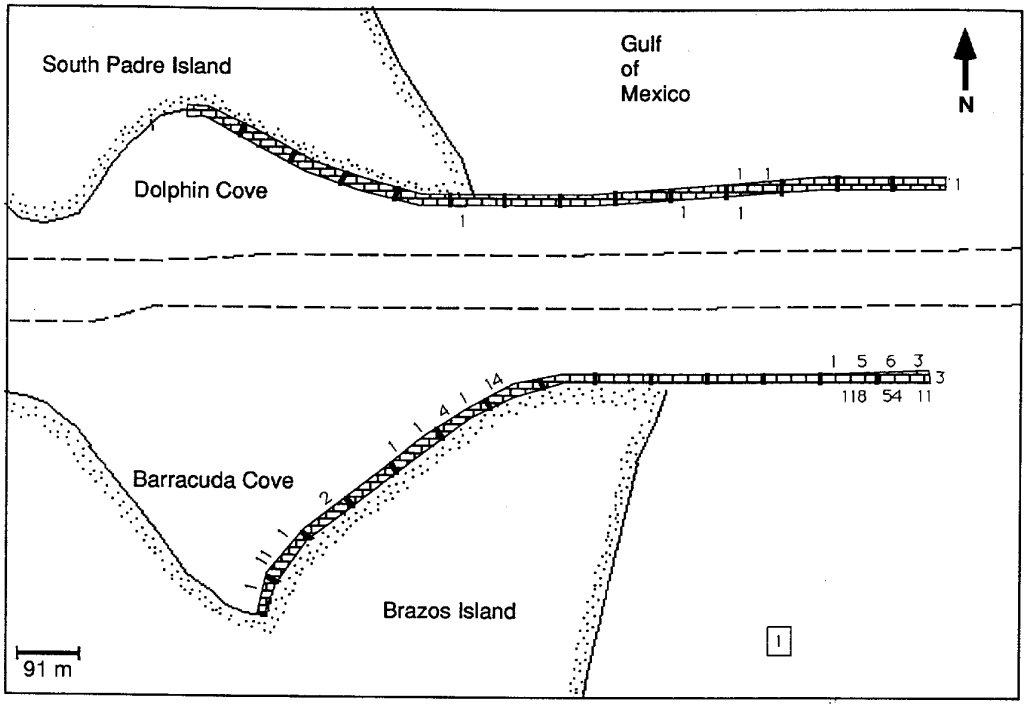


Figure 17. Opportunistic sightings of sea turtles from 31 Jul to 15 Oct 1992 by NMFS personnel. The number of sightings near the Brazos Santiago pass jetty is indicated on the map.